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October 10, 2002

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Marlene H. Dortch, Secretary
Federal Communications Commission
Office of the Secretary
445 12th Street, SW
Washington, DC 20554

Re: *Progeny LMS, LLC Petition for Rulemaking to Amend Part 90 of the Commission's Rules Governing Location and Monitoring Service To Provide Greater Flexibility, RM-10403.*

Ex Parte Presentation

Dear Ms. Dortch:

Counsel for Progeny LMS, LLC hereby requests that the enclosed white paper, *LMS Compatibility with Part 15 Devices: The Case for Spectrum Flexibility,* be tiled in the record of the above-captioned rulemaking docket. Progeny submits this white paper, which analyzes whether there is any significant increased risk of interference that could be caused by granting Progeny's pending petition for flexibility in the 902-928 megahertz band. Employing a real-world analysis of technical characteristics and network deployment, the white paper indicates that flexibility would result in no greater potential for harmful interference than unlicensed Part 15 devices currently pose to each other within the 902-928 MHz band.

In its March 5, 2002 petition for rulemaking, Progeny sought the elimination or modification of rules that: (1) prevent the aggregation of existing multilateration LMS sub-bands; (2) restrict real-time interconnection with the public switched telephone network (PSTN); (3) restrict the types of communications or services that LMS operators may provide; and (4) require field-testing of LMS devices and establish a "safe-harbor" presumption of noninterference to LMS operations by unlicensed wireless devices.

In accordance with Section 1.1206(b) of the Commission's Rules, please accept this original and one copy for submission. Should you have any questions or concerns in connection with this submission, please contact me at (202) 371-9100.

Respectfully yours,

Albert Halprin
Counsel

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Kathleen Ham, WTB
David Furth, WTB
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White Paper

LMS Compatibility with Part 15 Devices:
The Case for Spectrum Flexibility

Progeny LMS, LLC **October 8, 2002**

Contents

1 Introduction

This White Paper was prepared on behalf of Progeny LMS, LLC, in support of its Petition for Rulemaking (RM-10403), filed on March 5, 2002. The paper seeks to provide a technical framework for addressing an area of concern raised by companies filing comments in this proceeding. That concern, stated as a question, is:

> Will additional flexibility for LMS systems cause unacceptable levels of interference to Part 15 devices?[1]

This paper presents the technical design parameters of a Location and Monitoring Service (LMS) network and analyzes several real-world cases of interference Part 15 devices. The technical framework described in this paper, and the specific interference scenarios presented, is intended to be illustrative, using reasonable assumptions about technical parameters and deployment scenarios. Given the wide range of Part 15 devices, an exhaustive interference analysis is beyond the scope of this paper.

This paper demonstrates, however, that additional flexibility for LMS systems will not cause an unacceptable level of interference to Part 15 devices. This paper further demonstrates that even "high-density"[2] LMS systems do not present an interference risk to Part 15 devices that is greater than the inherent interference risk already present from other Part 15 devices.

2 LMS Network Parameters

This section defines the fundamental engineering parameters that must be considered when designing and deploying an LMS network. Nominal values are established for all of the parameters based on industry standard practices and extensive experience in real world deployments.

The network parameters – and their nominal values as established in this paper – are intended to provide a framework for assessing both the performance and potential interference risks associated with a general purpose, flexible LMS network. In some cases, severe interference cases are examined in order to facilitate a high-confidence, conservative analysis. These cases are intended to provide worst-case examples and are not proposed as a litmus test for Part 15 protection.

2.1 Potential LMS Services

In order to evaluate the potential impact to Part 15 devices from an LMS network, the parameters of a hypothetical LMS network are described below. To consider the worst-case LMS impact to Part 15 devices, a "high-density" LMS network is utilized, i.e., a network with sufficient base station density to provide in-building coverage. While LMS may have originally been considered primarily a vehicular service (which would not require in-building service) many LMS applications may indeed require such service ubiquity. Tracking inventory. enabling delivery confirmations and receiving telemetry from meters or vending machines are just a few examples. Of course, some LMS providers may deploy lower density networks to effectively provide vehicular or other

[1] *Unless explicitly noted to the contrary, all references to Part 15 devices in this paper are to devices operating in the 902-928 MHz band. All references to LMS systems in this paper are to Multilateralion LMS systems.*

[2] *"High-densify" LMS systems are described below as systems deployed extensively enough to provide a high degree of in-building service. These high-density LMS systems are believed to present the worst case interference risk to Pari 15 devices.*

services. but the LMS network described in this paper represents the maximum impact on Part 15 that an LMS network could reasonably be expected to cause.

LMS systems will likely deploy packet data networks to provide LMS services. Such LMS services may include tracking vehicles, equipment, inventory and packages for business, public safety and personal applications. These LMS services will involve "bursty" data transmissions. Ancillary voice service. most likely carried as IP packets ("voice over IP" or VoIP), may be an important component of LMS service offerings. However, LMS is not expected to be another cellular voice service. The cellular voice market already has too many competitors and financing yet another entrant is very unlikely. Instead, Progeny expects LMS systems to carry location data, identification information, status data, source/destination information, schedule information, expiration information, price information, ancillary voice traffic, imaging data, dispatching information, software updates and remote troubleshooting information.

2.2 Deployment Configurations for an LMS Network

In order to provide ubiquitous coverage and control costs, an LMS network will likely utilize existing structures for base station deployments. In urban areas, a typical LMS base station will be deployed on building rooftops. High-gain directional antennas will be used to achieve the allowed 30 watt ERP and maximize uplink coverage. Typically, this will involve a three-sector configuration with two antennas in each sector for receive diversity. Actual antenna deployments are dependent on the system architecture. Generally, it is economical to duplex transmit and receive functions into one or both sectorized antennas to minimize the number of antennas, since rooftop rents usually increase with additional antennas. For some architectures, it is desirable to use low noise amplifiers (LNAs) at the receive antennas to maximize uplink coverage.

In suburban areas, LMS systems will typically **use** building rooftops, where sufficiently tall buildings are available, or existing monopoles and tower structures. For this evaluation, collocation on an existing monopole is assumed. Generally, suburban deployments will also involve three-sector configurations with similar antenna deployments as urban environments.

For this evaluation, a Decibel Products DB876G90A-XY panel antenna with 16 dBi gain and a 90° horizontal beamwidth is utilized. This antenna represents a typical antenna that could be utilized for an LMS network deployment. The antenna specification sheet is attached as Exhibit 1.[3] The antennas used in this analysis are mechanically downtilted. **so** that the 3 dB point above the main lobe on the antenna's vertical pattern is oriented at the base station coverage boundary (at the radius of the hexagonal "cell"). Antenna downtilting, particularly in urban areas, is a practical means of maximizing coverage and minimizing interference.

2.3 Link Budgets

A link budget examines transmitted power, gains and **losses** in the transmission path to determine the base station coverage radius. Link budgets are examined for both the downlink (or forward link) from the base station to the mobile device and the uplink (or reverse link) from the mobile device to the base station. A typical link budget for the downlink in an urban environment is presented below:

Urban Link Budget
Downlink (base station to mobile)

			Watts
r		1B	
Transmission /(	losses	3.0 1B	

[3] *More information can be obtained at w.decibelproducts.com.*

Antenna input power	30.9 dBm	1.2
Antenna gain	16.0 dBi	
Effective Isotropic Radiated Power (EIRP)	46.9 dBm	49.2
Effective Radiated Power (ERP)	44.8 dBm	30.0
Building penetration loss	15.0 dB	
Mobile device antenna gain	2.2 dBi	
Mobile device antenna connector loss	0.2 dB	
Interference margin	12.0 dB	
Receiver threshold	-105.0 dBm	
Maximum propagation loss	126.9 dB	

LMS systems are allowed a maximum of 30 watts ERP in 95% of the licensed frequencies. The remaining 5% of the licensed frequencies (927.25-928 MHz) are allowed 300 watts ERP on the forward link. The analyses presented in this paper pertain only to the portion of the LMS spectrum with the 30 watt ERP limit. The remaining portion of the licensed LMS spectrum constitutes less than 3% of the total 902-928 MHz band, and it is believed that the interference impact to Part 15 devices of the higher power in this portion of the band is minimal. Such an analysis is beyond the scope of this paper.

As can be seen from the link budget figures, the 16 dBi gain antenna allows an LMS base station to meet its 30 watt ERP limit with a 2.5 watt transmitter. This calculation assumes a 3 dB loss in the transmission line and connectors, which is typical for rooftop installations. It should be noted that EIRP (power relative to an isotropic antenna) is higher than ERP (power relative to a dipole), by the gain of a dipole antenna relative to an isotropic antenna, i.e., 2.15 dB.

Although building penetration losses vary widely from building to building, an allowance of 15 dB for building penetration loss in an urban area is consistent with experience at 900 MHz for ubiquitous mobile systems. This building penetration factor has a significant impact on base station coverage and thus the number of base stations required to serve a given area. This assumption is consistent with the "high-density" LMS network for examining maximum impact to Pad 15 devices. In some of the interference scenarios presented later, a lower building penetration loss *(6* dB) is used to analyze the worst-case scenario of interference to a Part 15 device located near the window of an office building. This assumption is also consistent with experience at 900 MHz.

Other factors used in the link budget calculation also represent reasonable assumptions. The mobile device is assumed to have a half-wave dipole antenna and a small connector loss. There is a wide range of possibilities for LMS mobile units, but for purposes of link budgeting, a portable device in a building with a dipole antenna represents a good design assumption. The interference margin is included recognizing the "noisy" RF environment in the 902-928 MHz band: fade margin is included in the interference margin figure

The receiver threshold is the minimum signal power necessary for acceptable performance of the receiver for a given quality specification, such as bit error rate. Receiver threshold is dependent upon the thermal noise, which is dependent upon the signal bandwidth, and the noise figure of the receiver, which is dependent upon the design and manufacturing of the receiver. Over the range of possible LMS signal bandwidths, signal modulations, performance requirements and cost factors, the assumed receiver threshold is consistent with receiver thresholds for other 900 MHz devices.

The maximum propagation loss is calculated from the factors discussed above. Since propagation loss increases with distance, this figure allows us to determine the maximum coverage radius of the base station. Before making that determination, it is necessary to examine the uplink link budget. If the maximum propagation loss for the uplink is less than the downlink, then base station coverage is limited by the uplink.

Urban Link Budget
Uplink (mobile to base station)

		Watts
Transmitter power output	30.9 dBm	1.2
[illegible]	[illegible]	
Antenna input power	30.7 dBm	1.1
Antenna gain	2.2 dBi	
Effective Isotropic Radiated Power (EIRP)	32.9 dBm	1.9
Effective Radiated Power (ERP)	30.7 dBm	1.2
Building penetration loss	15.0 dB	
Base station receive antenna gain	16.0 dBi	
Transmission line/connector losses	3.0 dB	
Interference margin	12.0 dB	
Receiver threshold	-108.0 dBm	
Maximum propagation loss	126.9 dB	

This budget uses the same assumptions as the downlink, with the exception of the mobile device transmitter power and receiver threshold. In general, there are many more mobile devices than base stations and it is desirable to keep mobile device costs low. While low cost is also desirable for base stations, it is practical to have better performing, more expensive receivers at the base stations. Better base station performance minimizes the number of base stations required for ubiquitous service, lowering overall system costs. Consequently, the base station receiver sensitivity is assumed to be 3 dB lower than the mobile device threshold.

Since there are many possible types of LMS mobile devices, the 1.2 watt transmitter is a reasonable assumption. Some types of LMS mobile devices might utilize higher-power transmitters. For LMS systems supporting those devices, higher-gain mobile device antennas or better mobile receiver performance would allow larger base station coverage areas. Some LMS devices, such as those used regularly in close proximity to the human body, might utilize lower power transmitters. LMS systems supporting those types of devices might utilize receive antenna LNAs to equalize the uplink and downlink link budgets.

Under the link budget assumptions discussed above, the maximum propagation losses are the same for the downlink and the uplink.

For suburban environments, a building penetration factor of 10 dB is used. This factor is consistent with the high-density LMS network assumption and consistent with building loss assumptions for other 900 MHz networks.

Suburban Link Budget
Downlink (base station to mobile)

		Watts
Transmitter power output	33.9 dBm	2.5
Transmission line/connector losses	3.0 dB	
Antenna input power	30.9 dBm	1.2
Antenna gain	16.0 dBi	
Effective Isotropic Radiated Power (EIRP)	46.9 dBm	49.2
Effective Radiated Power (ERP)	44.8 dBm	30.0
Building penetration loss	10.0 dB	
Mobile device antenna gain	2.2 dBi	
Mobile device antenna connector loss	0.2 dB	

Interference margin	12.0 dB	
Receiver threshold	-105.0 dBm	
Maximum propagation loss	131.9 dB	

Again, with these assumptions, the maximum propagation loss is the same for uplinks and downlinks.

Suburban Link Budget
Uplink (mobile to base station)

		Watts
Transmitter power output	30.9 dBm	1.2
Antenna connector loss	0.2 dB	
Antenna input power	30.7 dBm	1.1
Antenna gain	2.2 dBi	
Effective Isotropic Radiated Power (EIRP)	32.9 dBm	1.9
Effective Radiated Power (ERP)	30.7 dBm	1.2
Building penetration loss	10.0 dB	
Base station receive antenna gain	16.0 dBi	
Transmission line/connector losses	3.0 dB	
Interference margin	12.0 dB	
Receiver threshold	-108.0 dBm	
Maximum propagation loss	131.9 dB	

2.4 Propagation Models

2.4.1 Outdoor Propagation Model

To calculate the base station coverage area, a propagation model is selected that is appropriate for this type of network. Several industry standard propagation models were examined, and the COST-Walfisch-Ikagami-Model (COST-WI)[4] was selected. The Wireless Communications Technology Group (WCTG) of the National Institute of Standards and Technology describes this model as follows:

> "In Europe, research under the Cooperation in the Field of Scientific and Technical Research (COST) program has developed improved empirical and semi-deterministic models for mobile radio propagation. In particular, Project 231 (COST 231), entitled 'Evolution of Land Mobile Radio Communications,' resulted in the adoption of propagation modeling recommendations for cellular and PCS applications by the International Telecommunications Union (ITU), including a semi-deterministic model for medium-to-large cells in built-up areas that is called the Walfisch-Ikegami model. The Walfisch-Ikagami model (WIM) has been shown to be a good fit to measured propagation data for frequencies in the range of 800 to 2000 MHz and path distances in the range of 0.02 to **5** km."[5]

The COST-WI model uses parameters for building heights, road widths, building separations and road orientations to characterize the RF environment. The model distinguishes between line-of-sight (LOS) and non-line-of-sight (NLOS) cases with different propagation formulas. Based on measured data analyses, the formula for LOS cases is different from free-space path loss using a distance term to the power of 2.6 rather than distance squared. The NLOS case uses a term for

[4] **See** *'Digital Mobile Radio Towards Future Generations,* ***Cost*** *231 Final Report", chapter 4, pages 135140 (Cost 231 Final Report). This* ***can be*** *found at* www.lx.it.pt/cost231.

[5] **See** *w3.antd.nist.gov/wctg/manet/calcmodels_dstlr.pdf*

LMS base station antenna height	(h_{base})	200 ft AGL[6]	61.0 m AGL
LMS mobile device antenna height	(h_{mobile})	6 ft AGL	1.8 m AGL
heights of buildings	(h_{roof})	180 ft AGL	54.9 m AGL
widths of roads	(W)	50 fl	15.2 m
building separation	(b)	100 ft	30.5 m
road orientation	(φ)	90 degrees	

LMS base station antenna height	(h_{base})	150 ft AGL	45.7 m AGL
LMS mobile device antenna height	(h_{mobile})	6 ft AGL	1.8 m AGL
heights of buildings	(h_{roof})	35 ft AGL	10.7 m AGL
widths of roads	(W)	60 fl	18.3 m
building separation	(b)	120 fl	36.6 m
road orientation	(φ)	90 degrees	

[6] ***Above Ground Level.***

[7] ***See Cost*** *231* ***Final Report. chapter 4, pages*** *176-179*

L is the propagation **loss** in dB
L_0 is the path **loss** at 1 m
n is the power decay index
d is the distance in m

The factors L_0 and n are based on measured data and supplied for various environments.

2.5 LMS Base Station Coverage and Density

To determine the density of LMS base stations necessary to cover an area, a theoretical hexagonal base station grid is assumed. Actual deployments, of course, never precisely tit this grid pattern, but it is a reasonable assumption for approximating the number of base stations required for coverage. Using the coverage radius as the distance from the hexagon's center to a vertex allows for some coverage overlap on each of the hexagon's side. The hexagon then describes the unique coverage area of each base station.

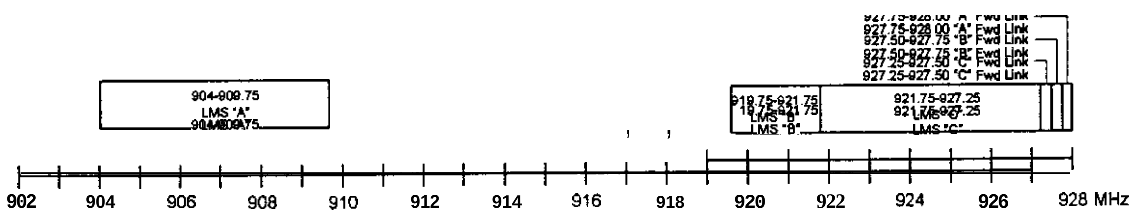
Using the COST-WI model with the assumptions outlined above, the high-density urban base station coverage radius was calculated to be 0.27 miles (0.44 kilometers), yielding an equivalent coverage area of 0.19 square miles, or 5.2 LMS base stations per square mile. Likewise, the high-density suburban base station coverage radius was calculated to be 2.2 miles (3.6 kilometers), yielding an equivalent coverage area of 13.0 square miles and a density of less than one LMS base station every 10 square miles.

3 Interference Analysis

3.1 Band Occupancy

Part 15 devices must operate in an uncontrolled environment in which other Part 15 devices are present, making interference a fact of life in the 902-928 MHz band. Devices deployed in this band are designed to tolerate such an environment and may employ frequency agility to avoid interfering sources. Frequency agile architectures such as frequency hopping (FH) and digitally modulated (DM) spread spectrum are tolerant of nearby interfering sources. In an FH system, for example, interference from another FH system is the statistical likelihood that the two systems transmit on the same frequency at the same time. Interfering power in a portion of the band not used at that exact moment does not negatively impact performance of a Part 15 device.

The fact that multilateration LMS spectrum constitutes only about half of the 902-928 MHz band (see below) is a major factor in minimizing potential interference to Part 15 devices. For FH and other frequency-agile Part **15** devices, there is no possibility of collisions with multilateration LMS transmissions in nearly half the band; the same is not true of other Part 15 devices.



Another factor minimizing potential LMS interference to Part 15 is the nature of traffic in the band. Part 15 devices, as well as the services envisioned for LMS networks, rely on bursty data transmissions, which inherently experience lower collision rates. In addition to being bursty, many Part 15 devices in this band, such as some automatic meter reading and telemetry devices, are also low data-rate devices that are designed to transmit and retransmit until the data is successfully received. Finding a channel that is unoccupied for a sufficient duration to transmit and receive acknowledgement might require retransmissions in the presence of interfering signals. For higher data rate devices, many automatically reduce their data rates as the carrier-to-interference ratio becomes degraded.

3.2 Interference Scenarios

The interference scenarios examined below are based on reasonable assumptions. It is recognized that catastrophic interference cases could be devised, but Part 15 is not an environment in which interference protection from outlying cases is expected. Indeed, the Commission addressed the issue of absolute interference protection to Part 15 in the LMS proceeding:

> "The language in the Order on Reconsideration cited by Pinpoint does not mean that Part 15 devices are entitled to protection from interference. They are not."[8]

Instead, when reasonable assumptions demonstrate that LMS networks will not create interference risks to Part 15 devices significantly greater than the inherent risks from other Part 15 devices, then it is clear that LMS networks will not cause unacceptable levels of interference to Part 15 devices.

FH and DM Part 15 devices operating under Section 15.247 of the FCC Rules are allowed 1 watt maximum peak output power and a 6 dBi antenna. Thus, these devices can operate with 4 watts (36.0 dBm) EIRP. The maximum Part 15 EIRP calculation is shown below.

Part 15 Maximum EIRP Calculation

		Watts
Transmitter power output	30.2 dBm	1.1
Antenna connector loss	0.2 dB	
Antenna input power	30.0 dBm	1
Antenna gain	6.0 dBi	
Effective Isotropic Radiated Power (EIRP)	36.0 dBm	4.0

Comparing maximum power levels, LMS systems are allowed 46.9 dBm EIRP which is 10.9 dB higher than the FH and DM Part 15 devices. At first blush it might appear than LMS systems will present a greater interference threat than other Part 15 devices, but as we will see, the effect of the larger LMS EIRP is reduced by the antenna's vertical radiation pattern and balanced by the proximity and number of Part 15 devices.

In analyzing potential interference from an LMS base station, the vertical pattern of the antenna is utilized. The maximum ERP occurs on the main lobe of the vertical pattern. Radiation at any other elevation angle is reduced from the maximum. A tabulation of the antenna's vertical radiation pattern from the manufacturer was used in these analyses.

As stated above, base station antennas are typically mechanically downtilted to utilize the radiated power in the service area and reduce potentially interfering radiation towards other base station coverage areas. The 3 dB point above the main lobe of the antenna's vertical pattern was oriented towards the coverage boundary. Using the assumptions outlined above, for the urban environment, the optimum antenna downtilt was determined to be 12". Applying a similar analysis to the suburban environment, the optimum antenna downtilt was determined to be 5".

[8] ***Memorandum Opinion and Order and Further Notice*** of ***Proposed Rulemaking, Docket*** *93-61*, ***September*** *16, 1997*, ***paragraph 69***.

In a three-sector configuration, the angle between sector orientations is 120°. Using 90° horizontal beamwidth antennas, the ERP is slightly reduced in directions between sector orientations. Theoretically, this would reduce the base station's radiated power in those directions. However, experience in urban deployments has shown improved performance using 90° antennas over 120° antennas. In order to make this analysis conservative, the effects of the horizontal antenna pattern are not considered. Reductions in ERP in any direction (combination of azimuth and elevation angle) are only due to the antenna's vertical pattern. The maximum ERP is assumed at all azimuths on the main lobe of the antenna's vertical pattern.

3.2.1 Wireless Local Area Networks

		watts
Transmitter power output	18.2 dBm	0.07
Antenna connector loss	0.2 dB	
Antenna input power	18.0 dBm	0.06
Antenna gain	6.0 dBi	
Effective Isotropic Radiated Power (EIRP)	24.0 dBm	0.25

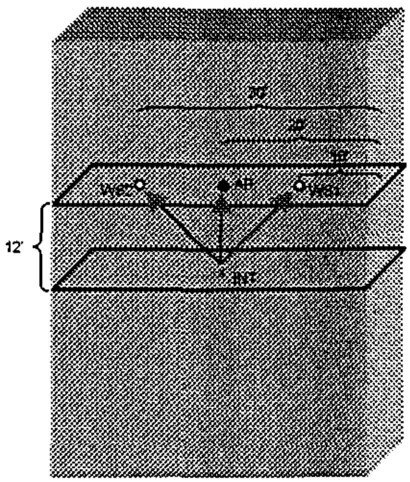


***Figure** 1. **The reduced power interfering Part** 15 **device** (INT) **is located one floor immediately below the** WLAN **access point (AP) and** 10 **feet horizontally offset from** two **WLAN workstations (WS1 and** WS2).*

We use the ISM indoor propagation model with the "two floors" **factors.**[9] There is no frequency adjustment to L_0 for the 'two floors" case. We have assumed **12** feet per floor. A comparison between the **ISM** path **loss** and free space path **loss** is also provided. The power decay is distance to the **5.2** power as compared to distance squared in the free-space path loss. For AP we assume a 6 dBi antenna gain is used to maximize **WLAN** coverage in the office space. For WS1 and **WS2** we assume that the workstations use a wireless modem card with an antenna gain of **2.15** dBi. These are reasonable assumptions, but in a comparison of interfering power levels, the actual antenna gains are immaterial since both interfering sources are received by the same antenna.

We do not include vertical pattern effects of the Part 15 devices. For these antennas, the vertical patterns are extremely broad and the orientation of these antennas in an indoor oftice environment is unknown. Furthermore, due to the nature of indoor propagation, the effect of the vertical radiation pattern would be very difficult to model, even with a complex ray tracing analysis and a detailed physical model of the office. Certainly, for this analysis using very low gain antennas, assuming the maximum antenna gain from the Part 15 devices is reasonable.

Exhibit **2** (attached) shows the interfering powers received at WS1, AP and **WS2** from the INT device.

To compare the interfering power from the LMS system with the Part **15** interfering power, we examine the case where the **WLAN is** in the building across the street from, and in line-of-sight of, the **LMS** base station. We examine cases where the WLAN is 100, **125,** 150 and **175** feet above ground level (Figure **2).** This is considered to be a severe interference case.

[9] ***For this model. one floor means** the **same floor, two** floors **means adjacent** floors **and multi-floor means more than** two floors.*

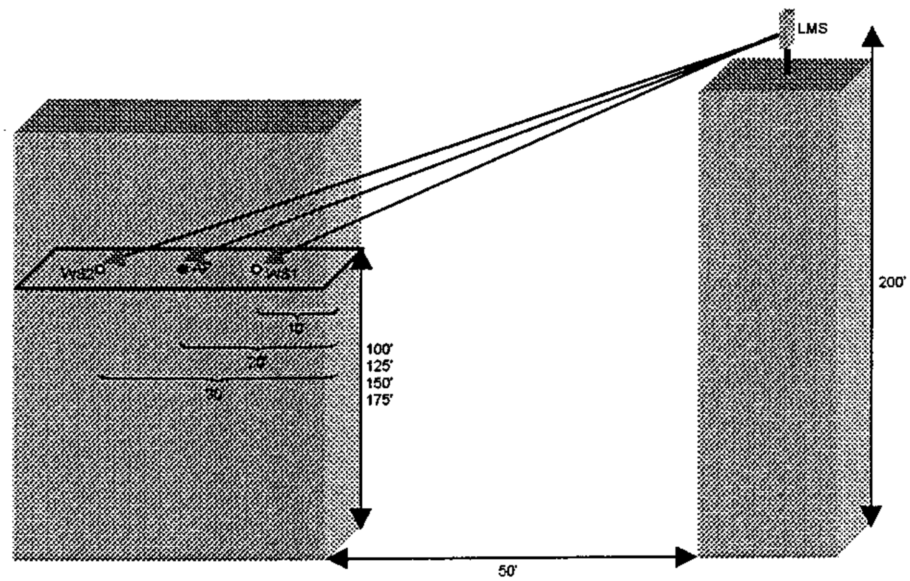


Figure 2. An LMS antenna mounted on the roof a building immediately across the street from a WLAN deployment. Interference is calculated at different heights of the WLAN deployment.

For this case, we use the COST-WI LOS mode with a 15 dB building penetration **loss** applied to AP and WS2. For WS1, which is located in an exterior office with a window, we assume only a **6** dB penetration **loss.** We use the vertical radiation pattern of the LMS base station because it is a high-gain antenna that has been engineered with mechanical downtilt and professionally installed.

Exhibit 3 (attached) shows the calculation of the interfering power levels received at WS1, AP and WS2 from the LMS base station.

Comparing Exhibits 2 and 3, the interfering power level of the INT device one floor below the WLAN is higher than the LMS interfering power level in all virtually cases. The interfering power level from the INT device at **AP** is greater than that from the LMS base station by as much **as 35.6** dB. Even for the AP located 175 feet AGL, the interfering signal from the INT device **is 8.4** dB higher. For WS1, which is in an office with a window across the street from the LMS base station, the interfering power level from the INT device is higher in all cases and by as much as **24.6** dB. For WS2, the interfering power level from the INT device is as much as 21.0 dB higher. Only in the case of WS2 located 175 feet **AGL,** is the interfering power level from the LMS base station higher than that from the INT device. In that case, the difference is less than 0.5 dB.

It should be noted that this interference case using offices across the street from the LMS base station is a severe test and should not be the standard by which LMS systems are held. LMS systems should not be expected to provide absolute interference protection. If, over the vast majority of the coverage area, LMS systems do not prevent Part 15 devices from being deployed and operating as they might reasonably be expected to operate, then LMS systems have not caused an unacceptable level of interference to Part 15 devices.

From an examination of the relative interfering powers, we conclude that even in a severe interference case, the LMS base station does not present interfering power levels significantly greater than interfering power levels from other Part 15 devices. When coupled with band occupancy considerations, we conclude that LMS base stations will not cause an unacceptable level of interference to Part 15 devices.

3.2.2 Ricochet

Ricochet also filed comments in this proceeding expressing concerns about interference from LMS systems.[10] Aerie Networks purchased the Ricochet assets from Metricom, *Inc.*, which **filed** for bankruptcy in July **2001.** It is believed that Denver, CO is the only city in the country where the Ricochet service is available. An interference case to the Ricochet Pole Top Radio (PTR) is described below.

Ricochet uses a FH technology in the **902-928 MHz** band for the system uplink, that is, from subscriber modem cards to the PTR. The **2.4** GHz band is used from the PTR to the Wired Access Point (WAP) and thus is outside the band of interest. For this calculation, we have assumed the PTR is on a utility pole 15 feet AGL in the urban environment (Figure 3). We assume that another FH or DM Part **15** device with reduced EIRP is in an office with a window overlooking the PTR, 500 feet' away. Because of the urban clutter and the height difference, we assume that the LMS base station, separated 500 feet horizontally, does not have LOS propagation to the PTR.

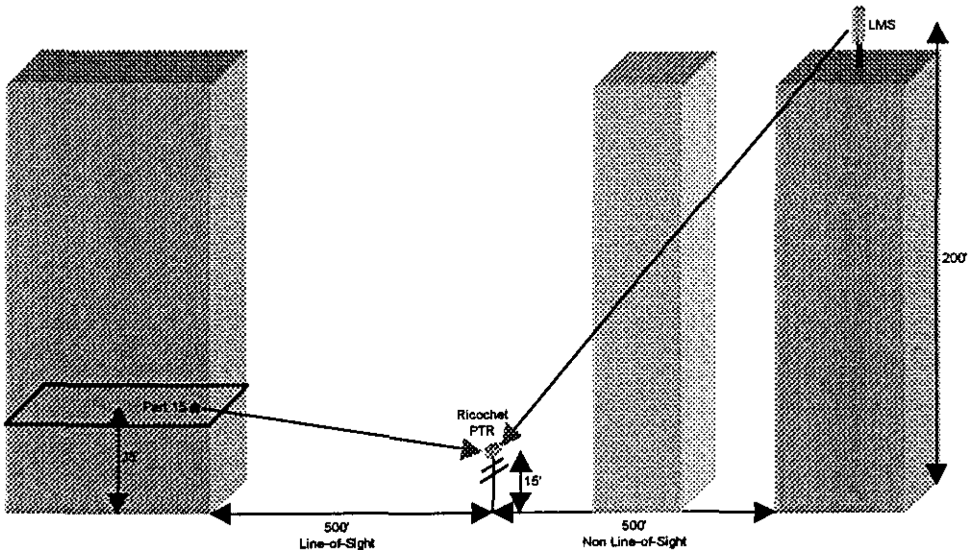


Figure 3. A Ricochet Pole** Top **Receiver (PJR) receives interference from a reduced power line-of-sight Part 15 device and a non-line-of-site LMS antenna.

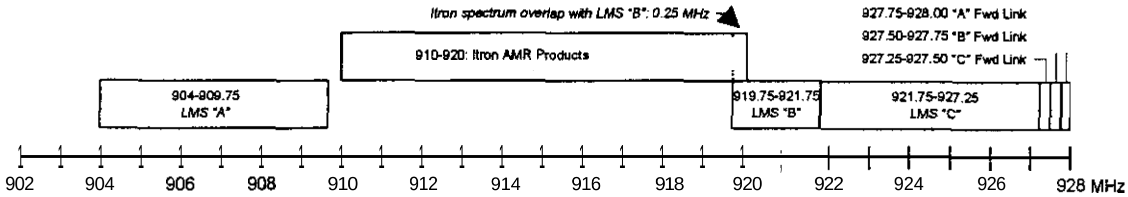
Exhibit **4** shows calculations comparing the interfering power levels at the PTR from another Part **15** device and from the LMS system. For the Part **15** device we have used the COST-WI LOS model plus a ***6*** dB penetration **loss** through the [illegible] window. With those assumptions, the Part **15** device produces an interfering power level of **–59.6** dBm. Using the COST-WI NLOS model for the LMS base station, the LMS interfering power level is **–71.6** dBm. In this scenario, the PTR experiences an interfering power level from the Part **15** device that is **12.0** dB higher than the interfering signal from the LMS base station.

3.2.3 Automatic Meter Readers

Several commenters in this proceeding (Itron Inc., Axonn, LLC and SchlumbergerSema Inc.) have expressed concern about interference protection of Part **15** Automatic Meter Reading (AMR) devices. Interestingly, a review of Itron's product line reveals that these products operate

[10] ***Ricochet Networks. Inc.***

in the **910-920** MHz band.[11] As can be seen from the chart below, there is virtually no overlap between Itron's products and licensed spectrum for multilateration LMS (0.25 MHz out of 10 MHz). Consequently, no interference to Itron's product is expected from LMS operations.



The majority of Axonn's product line appears to be programmable in eight 3 MHz steps across the **902-928** MHz band. Since that covers the entire band, it would also appear that Axonn products can operate entirely outside the LMS spectrum. SchlumbergerSema's Utilinet product is an FH device using **240 25** kHz channels in the **902-928** MHz band. This product is well designed to operate in an interference environment. The Network Performance Statistics include such parameters as the number of retries required to move a message to the next radio and the percentage of successful deliveries. According to the product brochure under Automatic Collision and Contention Management:

> "Should a message ever be blocked by interference on a given frequency, the radio automatically hops to a different frequency and tries again."

The impact of interfering power from an LMS system is to increase collisions on Utilinet frequency hops in the LMS half of the band when the bursty LMS transmissions happen to fall on the same frequency. The net impact is a potential increase in Utiiinet re-transmissions; exactly the same effect is present from other Part 15 devices.

To compare the interfering power at a meter reading device from another Part 15 device and an LMS base station, we assume the meter is in a suburban home (Figure 4). We assume that the meter transmits when polled by a nearby handheld or vehicle mounted device. We assume that the AMR device is 6 feet AGL.

As outlined above, in the suburban environment, the LMS base station density is less than one for every 10 square miles. It is reasonable, therefore, to assume that on average other FH or DM Part 15 devices will be in much closer proximity to the AMR device. We assume that such a Part 15 device is located 0.1 mile away, mounted above the shopping center roof, 50 feet AGL. For this suburban case, we assume that the Part 15 device is not one designed to operate in the indoor office environment. This interfering Part 15 device is assumed to be providing a "campus" type service covering the entire shopping center. For such a device, we assume the maximum allowed EIRP for the Part 15 device. As stated above, in the suburban environment, we assume that the LMS base station is located 150 feet AGL on an existing monopole. We assume that the monopole is 0.5 mile away. We use the COST-WI NLOS model for both the Part 15 device and the LMS base station.

[11] ***The MAS band frequencies (952 MHz and 957 MHz) are used by some Itron products but these frequencies are outside the band of interest.***

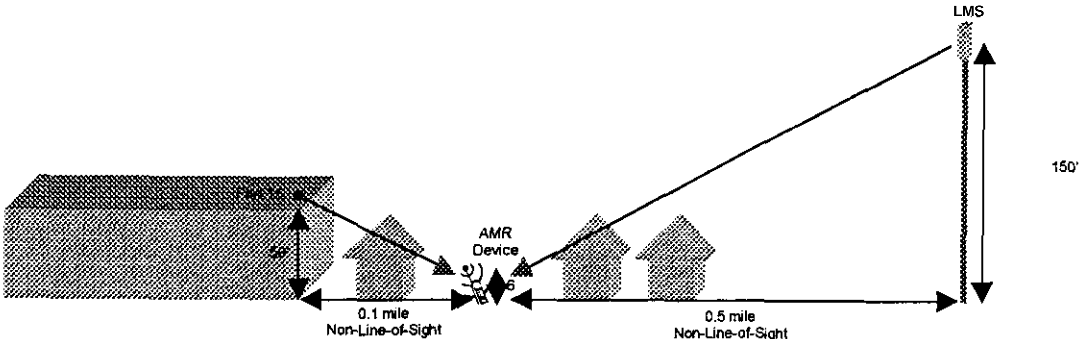


Figure 4. An Automatic Meter Reading (AMR) device receives non-line-of-sight interference from a Part 15 device located on a suburban shopping mall rooftop, and from an LMS antenna located on a nearby monopole.

As can be seen in Exhibit 5 (attached), under these assumptions, the interfering power from the Part 15 device is –57.1 dBm. The interfering power from the LMS base station is –58.5 dBm. Thus, the interfering power from the Part 15 device is higher than that from the LMS base station. At these heights and distances, the AMR is in the main lobe of the Part 15 antenna, so there are no vertical pattern effects. As can be seen in Exhibit 5, the effect of the LMS vertical pattern is minimal.

3.2.4 Cordless Telephones

A similar calculation is made to a Part 15 cordless phone located inside the home (Figure 5). In this case, a 10 dB home penetration factor is added to both interfering signal levels and we assume the cordless phone at 15' AGL.

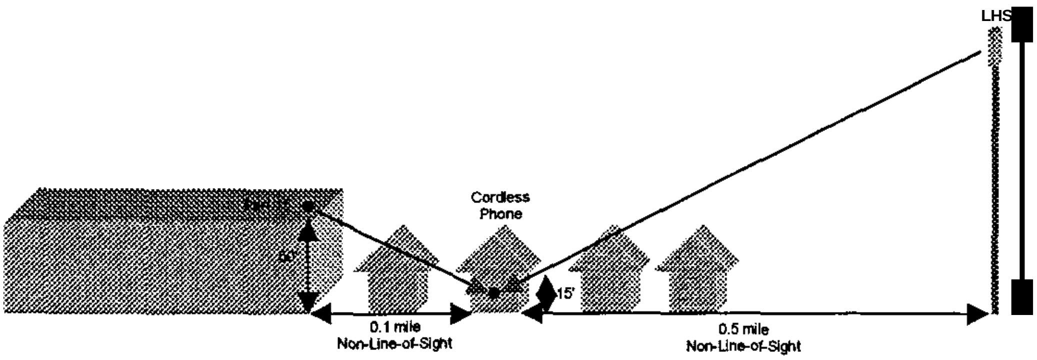


Figure 5. A residential cordless phone receives non- line-of-sight interference from a Part 15 device located on a suburban shopping mall rooftop, and from an LMS antenna located on a nearby monopole.

As can be seen in Exhibit 6 attached, the interfering power from the Part 15 device is -53.8dBm, while the interfering power from the LMS base station is –65.9 dBm. Thus, the interfering power from the Part 15 device is higher than that from the LMS base station.

3.2.5 LMS Mobile Devices

LMS mobile devices also present a potential interference source within the 902-928 MHz band. In general, since a base station supports many mobiles, base station transmissions are more frequent than mobile transmissions. Consequently, this analysis has focused on LMS base station transmissions. Since mobile transmissions are generally sporadic and (obviously) mobile, the interference potential may be higher due to proximity but much lower due to short duration. For the interference cases examined above, interfering signal power from a passing mobile is entirely consistent with the type of short duration interference Part 15 devices are designed to handle from other Part 15 devices. A comparison of LMS mobile devices with other Part 15 devices is beyond the scope of this paper.

3.3 Summary of Interference Analysis

The following table summarizes the various urban and suburban interference scenarios analyzed in this paper.

LMS Compatibility Study		
Urban Scenarios *LMS Antenna Height = 200 Feet (Rooftop)* *Height of Neighboring Buildings = 180 Feet* *Road width = 50 Feet* *Distance Between Buildings = 100 Feet*		
WLAN		
	Interfering Signal Strength	
WLAN Element Receiving Interference	Part 15 Device *1 floor directly below* *1SM Propagation* *Tx power 12 dB below max allowed*	LMS Antenna *Adjacent Rooftop* *COST-WI LOS Propagation*
WLAN Access Point *20 feet from building exterior* *100 feet above ground level*	-21.2 dBm	-49.8 dBm
WLAN Workstation *10 feet from building exterior* *100 feet above ground level*	-31.0 dBm	-55.6 dBm
WLAN Workstation *30 feet from building exterior* *100 feet above ground level*	-31.0 dBm	-51.7 dBm
Ricochet		
	Interfering Signal Strength	
Pole Tope Receiver Receiving Interference	Part 15 Device *500 feet away (line of sight)* *35 feet above ground level* *COST-WI LOS Propagation* *Tx power 12 dB below max allowed*	LMS Antenna *500 feet away (non-line-of-sight)* *Rooftop Mounted* *COST-WI NLOS Propagation*
Pole Top Receiver *15 feet above ground level*	-59.6 dBm	-71.6 dBm
Suburban Scenarios *LMS Antenna Height = 150 Feet (Monopole)* *Height of Neighboring Buildings = 35 Feet* *Road width = 60 Feet* *Distance Between Buildings = 120 Feet*		
Part 15 Devices		
	Interfering Signal Strength	
Part 15 Device Receiving Interference	Part 15 Device *Mounted on roof of shopping mall* *0.1 mile away (non-line-of-sight)* *50 feet above ground level* *COST-WI NLOS Propagation*	LMS Antenna *Monopole mounted* *0.5 mile away (non-line-of-sight)* *150 feet above ground level* *COST-WI NLOS Propagation*
Automatic Meter Reader *Hand held device* *6 feet above ground level*	-57.1 dBm	-58.5 dBm
Cordless Telephone *Locatedin private home* *15 feet above ground level*	-63.8 dBm	-65.9 dBm

4 Conclusion

The analyses contained in this paper illustrate that even "high-density" LMS systems do not present an interference risk to Part 15 devices significantly greater than the inherent interference risk from other Part 15 devices. The examination of comparative power levels, combined with band occupancy considerations, indicate that additional flexibility for LMS systems will not cause an unacceptable level of interference to Part 15 devices.

5 About the Authors

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DECIBEL PRODUCTS
Allen Telecom Company

DB876G90A-XY

13.5113.9 dBd
Wide Band Panel Antenna

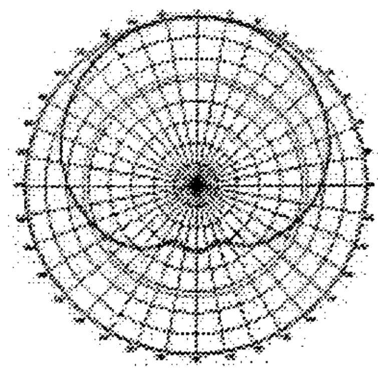
806-960 MHz

Gen 3VPol™
MaxGain™

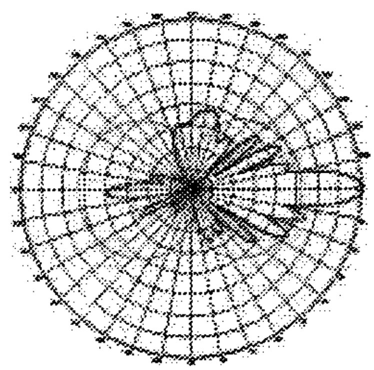
- 13.5 dBd (15.6 dBi) Gain - 806-896 MHz
- 13.9 dBd (16 dBi) Gain - 880-960 MHz
- Vertical Polarization
- 90° Azimuth BW
- 10° Elevation BW
- 7/16 DIN (Back)

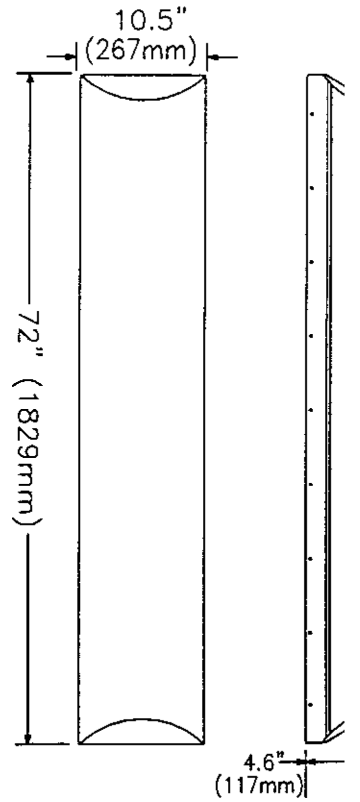
90°

Azimuth
(Horizontal)



Elevation
(Vertical)





Electrical

VSWR	< 1.33:1
Front-to-Back Ratio:	> 25 dB, typical
Max. Input Power:	500 Watts
Impedance:	50 Ohms
Lightning Protection:	All metal parts are grounded

Mechanical

Weight:	23 lbs (10.4kg)
Wind Area:	5.25 ft² (0.48 m²)
Frontal Thrust:	210 lbf (934N) 94 kp (at 100 mph)
Lateral Thrust:	92 lbf (409N) 41 kp (at 100 mph)
Max. Wind Speed:	125 mph (201 km/h)
Radiators:	Aluminum
Back Panel:	Pass. Aluminum
Radome:	ABS. UV Resistant
Mounting Hardware:	Galvanized Steel
Color:	Grav

Mounting Options

Standard:	DB380 pipe mount kit. included.
Downtilt:	DB5083 downtilt bracket, optional.

8635 Stemmons Freeway • Dallas, Texas U.S.A. 75247-3701
Dallas/Ft.Worth Area Tel: 214.631.0310 • Fax: 214.631.4706
Toll Free Tel: 1.800.676.5342 • Fax: 1.800.229.4706
www.decibelproducts.com
dbtech@decibelproducts.com

ISO9001 Compliant

Exhibit 2
Calculation of Interfering Power: Part 15 to WLAN

Freq (MHz)	915								
Lambda (m)	0.33								
	watts	dBm							
Maximum Allowed EIRP (dBm)	4	36.0							
Assumed Reduced EIRP (dBm)	0.25	24.0							
	(ft)	(m)							
Distance between floors	12	3.66							
Horizontal separation	10	3.05							
COST 231 1SM Model									
L_0	21.9								
n	5.2								
Case	Vertical Separation (m)	Slant Distance (m)	INT device EIRP (dBm)	Path Loss 1SM Dense (dB)	Antenna Gain (dBi)	WLAN Rx Power (dBm)		Free Space Path Loss (dB)	Loss Above FSPL (dB)
INT to WS1	3.66	4.76	24.02	57.14	2.15	-30.97		45.23	11.9
INT to AP	3.66	3.66	24.02	51.19	6.00	-21.17		42.94	8.2
INT to **WS2**	3.66	4.76	24.02	57.14	21.5	-30.97		45.23	11.9

Exhibit 3
Calculation of Interfering Power: LMS to WLAN

Freq (MHz)	915	
Lambda (m)	0.33	
Maximum LMS EIRP (dBm)	46.92	
	(ft)	(m)
LMS Base Station Antenna Height (AGL)	200	61.0
Width of road	50	15.2
WS1 distance from building exterior	10	3.0
AP distance from building exterior	20	6.1
WS2 distance from building exterior	30	9.1

Case	WLAN Height (ft AGL)	WLAN Height (m AGL)	Horizontal Distance (m)	Slant Dist (m)	Depression Angle	LMS Antenna dB down	LMS EIRP (dBm)	Building Penetration Losses (dB)	COST-WI LOS (dB)	WLAN Rx Antenna Gain	WLAN R Power (dBm)
LMS to WS1	100	30.48	18.29	35.55	59.04	34.50	12.42	6.00	64.15	2.15	-55.5
LMS AP	100	30.48	21.34	37.21	55.01	23.10	23.82	15.00	64.66	6.00	-49.8
LMS to ws2	100	30.48	24.38	39.03	51.34	20.60	26.32	15.00	65.21	2.15	-51.7
LMS to WS1	125	38.10	18.29	29.28	51.34	20.60	26.32	6.00	61.96	2.15	-39.4
LMS to AP	125	38.10	21.34	31.27	46.97	32.00	14.92	15.00	62.70	6.00	-56.7
LMS to WS2	125	38.10	24.38	33.42	43.15	22.60	[illegible]	15.00	63.45	2.15	-51.9
LMS to WS1	150	45.72	18.29	23.81	39.81	15.30	31.62	6.00	59.62	2.15	-31.8
LMS to AP	150	45.72	21.34	26.22	35.54	16.70	30.22	15.00	60.71	6.00	-39.4
LMS to WS2	150	45.72	24.38	28.75	32.01	21.10	25.82	15.00	61.75	2.15	-48.7
LMS to WS1	175	53.34	18.29	19.81	22.62	17.40	29.52	6.00	57.59	2.15	-31.9
LMS to AP	175	53.34	21.34	22.66	19.65	8.40	38.52	15.00	59.10	6.00	-29.5
LMS to WS2	175	53.34	24.38	25.55	17.35	4.10	42.82	15.00	60.46	2.15	-30.4

Exhibit 4
Calculation of Interfering Power: Ricochet

Freq (MHz)	915												
Part 15 to Ricochet - COST-WI LOS Model													
	(ft)	(m)											
Part 15 Antenna Height	35	10.7											
Ricochet Ant Height (AGL)	15	4.6											
LMS to Ricochet - COST-WI NLOS Model metropolitan centers													
	(ft)	(m)											
LMS Base Station Antenna Height (AGL)	200	61.0											
Ricochet Antenna Height (AGL)	15.0	4.6											
heights of buildings (h_{roof})	180	54.9											
widths of roads (w)	50	15.2											
building separation (b)	100	30.5											
road orientation (deg)	90												
L_{ori}	0.01												
L_{rts}	34.92												
L_{bsh}	-15.32												
k_a	54												
k_d	18												
k_f metropolitan	-4.00												
	Horizontal Separation (ft)	**Slant Distance** (m)	Maximum **EIRP** (dBm)	DepAng	**dB down** on vertical pattern	EIRP (dBm)	COST-WI LOS (dB)	Free Space Path Loss (dB)	COST-WI L	COST-WI NLOS (dB)	Penetration **Loss (dB)**	Ricochet Rx Gain (dBi)	Ricochet Rx Power (dBm)
Part 15 to Ricochet	500	152.5	24.02			24.02	80.60				6.0	3.0	-59.58
LMS to Ricochet	500	162.5	46.92	20.3	11.5	35.42		75.85	-0.72	110.04		3.0	-71.62

Exhibit 5
Calculation of Interfering Power: AMR

Freq (MHz)	915										
	Part 15			LMS							
	(ft)	(m)		(ft)	(m)						
Antenna Height (AGL)	50	15.2		150	45.7						
AMR Antenna Height (AGL)	6.0	1.8		6.0	1.8						
heights of buildings (h_{roof})	35	10.7		35	10.7						
widths of roads (w)	60	18.3		60	18.3						
building separation (b)	120	36.6		120	36.6						
road orientation (deg)	90			90							
L_{ori}	0.01			0.01							
L_{rts}	19.03			19.03							
L_{bsh}	-13.43			-28.02							
k_a	54			54							
k_d	18			18							
k_f suburban	-4.00			-4.00							
	Horizontal Separation (mi)	Slant Distance (m)	Maximum EIRP (dBm)	DepAng	dB down on vertical pattern	EIRP (dBm)	Free Space Path Loss (dB)	COST-WI L_{msd}	COST-WI NLOS (dB)	AMR Rx Gain (dBi)	AMR Rx Power (dBm)
Part 15 to AMR	0.1	161.5	36.02			36.02	75.79	0.40	95.23	2.15	-57.06
LMS to AMR	0.5	805.9	46.92	3.12	0.4	46.52	89.75	-1.63	107.16	2.15	-58.49

Exhibit 6
Calculation of Interfering Power: Cordless

Freq (MHz)	915											
	Part 15			LMS								
	(ft)	(m)		(ft)	(m)							
Antenna Height (AGL)	50	15.2		150	45.7							
Cordless Antenna Height (AGL)	15.0	4.6		15.0	4.6							
heights of buildings (h_{roof})	35	10.7		35	10.7							
widths of roads (w)	60	18.3		60	18.3							
building separation (b)	120	36.6		120	36.6							
road orientation (deg)	90			90								
L_{ori}	0.01			0.01								
L_{rts}	15.80			15.80								
L_{bsh}	-13.43			-28.02								
k_a	54			54								
k_d	18			18								
k_f suburban	-4.00			-4.00								
	Horizontal Separation (mi)	Slant Distance (m)	Maximum EIRP (dBm)	DepAng	dB down on vertical pattern	EIRP (dBm)	Free Space Path Loss (dB)	COST-WI L_{msd}	COST-WI NLOS (dB)	Penetration Loss (dB)	Cordless Rx Gain (dBi)	Cordless Rx Power (dBm)
Part 15 to Cordless	0.1	161.3	36.02			36.02	75.78	0.39	91.98	10.0	2.15	-63.8
LMS to Cordless	0.5	805.7	46.92	2.93	1	45.92	89.75	-1.63	103.93	10.0	2.15	-65.8